III.

NEUROPATHOLOGICAL CORRELATIONS WITH CLINICAL AND PSYCHOMETRIC FINDINGS IN FEEBLE-MINDEDNESS (WAVERLEY RESEARCH SERIES, CASES I–X.)

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The province of the present article is limited. We intend to make a provisional epicritical review of the problems presented by the first ten cases (I–X) of the Waverley Research Series of cases of feeble-mindedness. This term we use to include, not only feeble-mindedness proper (i. e., the so-called morons of recent American nomenclature), but also the subnormal persons above the grade of morons, which modern research is bringing into the field of feeble-mindedness, and also the imbeciles and idiots which lie below the grade of moron or of the feeble-minded proper. It is the plan of the present series of anatomical examinations, therefore, to work up successively a series of all types and grades of feeble-mindedness and subnormality without undue regard to their clinical classification or intelligence grading. Already, however, the data of our first ten cases have suggested certain lines of correlation which it seems worth while to set down here in the guise of provisional hypotheses.

Among all the problems sketched above (problems of the schools, the courts, the social agencies, the eugenics record offices, the biological laboratories, and the like), perhaps no problem is more acute than that of the significance and possible future of mental tests after the manner of Binet. We must leave to the psychologists the evaluation of the details of these tests and the construction and choice of new variants. We must leave to those versed in the statistics of mental measurement the decision how far the age level of the Binet tests and the percentage level of the Yerkes tests apply to actual conditions. We must concede forthwith that Binet left but a torso of what the future has in store in the shape of mental tests, and we may concede that these tests, for the most part, yield little information as to those emotional and volitional impulses, instincts, and sentiments which are so important in social life. On the whole, however, it is generally admitted that progress is being made to a more and more accurate measurement of mental capacities of certain sorts. This bit of progress is enough to brighten the path of the anatomist. The anatomist feels that he must follow far in the rear of the psychologist and physiologist in his analysis; particularly in his analysis of deviations and perversions which are of a qualitative nature or cannot readily be reduced to quantitative values. When, however, the anatomist learns

that psychometry is not merely an idle dream, but that distinct losses,— when, at any rate, these losses are of large degree,— are demonstrable and to a certain extent measurable, his hope is kindled that the brain itself may unexpectedly at least yield up a set of useful correlations.

What is the relation of mind to brain? Speculation halts shortly before the intricacies of this problem when it is taken as a problem of the relation of the full-blown, healthy mind with the entirely normal, richly active brain. Important light is thrown upon the topic, of course, by the anatomo-clinical method which yielded such rich data in the last half of the nineteenth century; for by this method definite losses of brain substance were often found to be associated with equally definite losses of mental power. The limitations of this method are numerous and need not detain us. The method has not been exhausted; but its future fruits depend upon elaborate tissue analyses which the ordinary laboratory and the ordinary scientific leisure available under our present institutional system do not permit. Almost equally rich results have accrued from work in comparative anatomy, latterly supplemented by behavioristic studies.

What we at present need is to supplement the methods of normal neurology and psychology, the methods of anatomo-clinical research, and the methods of comparative anatomy with a method which has alliances with each of these but seems to us to contain certain elements of novelty. It would be strange if the field of anatomy in feeblemindedness were not full of novelty since it had been so poorly tilled heretofore. The novelty in the anatomic situation with respect to feeble-mindedness seems to us to lie in the fact that we deal with all grades of defect, from an equality with brutes up to subnormality, hardly removed from ourselves, and thereby gain a number of steps upon what the comparative anatomist can ever take. It is conceded that the higher mental operations have much to do with speech,— its storage and its expression. Now, among animals few traces of speech exist. But among the feeble-minded all degrees of speech loss may in the course of years be studied. The missing links and intergrading transitions between the primates in general and man in particular may be found in feeble-mindedness. By proper sifting of cases, future investigation will discover by an accumulation of instances the minimum mechanism with which speech can be effected.

It is this principle of the minimum apparatus, the minimum machinery with which a function may be performed, that we regard as the most important and promising aspect of feeble-mindedness from the standpoint of research into mental function. As we have elsewhere sketched, fundamental researches in the psychology of efficiency may well be made with the feeble-minded, since among them we shall be able to discover what can be done with the least apparatus. For the purpose of the present argument we need not

develop the collateral fact, that in brain disease of the normal adult and in brain disease of epileptics we often deal with far more complicated problems since the destruction of a few bits of brain apparatus in one region may lead to functional disuse of great masses of mechanisms that are structurally quite intact. Diaschisis and shock are instances in point. There is no method of determining, at least in the majority of nerve cells, whether they are performing vegetative or conductive functions, or no functions whatever. Consequently the principle of discovering the minimum machinery with which a given act may be performed cannot be applied as a rule in the field of the neuropathology of destructive lesions.

Mill's method of study by means of concomitant variations is a method much more readily applied to material in feeble-mindedness than to the ordinary anatomo-clinical material of the neurological clinic.

Now, it must be conceded forthwith that, if the authorities in mental tests are in doubt as to their ultimacy, the brain anatomists are equally modest in their claims. As we looked over the claims of the workers in mental tests, we concluded that these mental tests could at least lay claim to a certain orderliness, such that a patient stated to have a mental age of six, was at all events of less mental capacity than one having a mental age of seven or eight. In short, the dicta of the mental tests might have an ordinal value if they did not possess cardinal value. Very possibly, also, this point might apply to the point-scale data of the Yerkes tests, although this perhaps was less likely on account of the fact that a given percentage in the Yerkes tests might be made up of exceedingly heterogeneous successes in puzzle-solving, the doing of sums, and the answering of questions. Conceding for the moment that the mental tests are now so good as to have approximately an ordinal value, such that a patient of eight years mental age has higher intelligence than a patient having a mental age of seven years, we can see that it might be well to compare our brains of feeble-minded subjects together so that we might learn whether here also there was an ordinal value to attach to the brains. We are, doubtless, far from the achievement of *cardinal* values, indicating definite increment of mental capacity to correspond with definite increment of brain mass, even should our studies be so minute as to permit us to evaluate the dendrite supply and synaptic surface area of the brain cells instead of their mere proportionate numbers. But might we not be able to arrange our brains in an ordinal series which would be convincing because of the derivation of the principles of arrangement from a number of sources: say, brain weight, proportionate brain weight to body length, complication of sulci, size of corpus callosum, etc., etc.?

And suppose this order of brains to be obtained, would it fit at all with the order of brains obtainable by mental tests? If the two series were largely identical, then might

not some progress be thought to have been made in the problem of the relation of intelligence to brain? We are, of course, entirely aware that this principle is applicable to a large series only, and the present tables are offered chiefly to lay down a few principles as to the proper lines of future correlation on the basis of more cases. We have placed at the head of Article II a statistical table of the ten cases in which some data for identification are given. In the following table, we again arrange the brains in their order of acquisition by the laboratory. In separate columns we place the age, mental age, brain weight (whether less or more than average according to our view), together with certain anatomical and histological data.

TABLE II.

TABLE DISPLAYING MAINLY HISTOPATHOLOGICAL FINDINGS, CASES I–X.

Number	Age	Mental Age	Brain Weight probably	Focal Destructive Lesion	Hydro-cephalus	Exudative Lesion of Rod Cells	Nerve Cell Aplasia	Fiber Loss	Gliosis	Satelli-tosis	Dislocated Ganglion Cells
I	5	1–, est.	minus	0	moderate	0	marked	marked	slight	0	0
II	20	1–, est.	minus	+	marked	0	marked	marked	marked, patchy	+	0
III	45	7, est.	minus	0	0	0	+	?	+	+	0
IV	62	moron or subnormal	plus	0	+	+	+	+	+	focal	+
V	16	subnormal	normal	0	slight	0	+	0	+	0 (sl) focal	+
VI	26	2, est.	minus	0	0	+ rod cells	slight	?	+	+	0
VII	25	5, Binet	normal	thrombus (Hist.)	0	rod cells	slight	?	+	0	0
VIII	36	subnormal	normal	0	0	+	+.	0	+	+	+
IX	39	7, Binet	plus	0	0	0	+	0	0	0	+, slight
X	37	24, Binet	plus	0	0	?	+	?	+	+	0

It will be seen that one case (II) is apparently the result of a focal destructive brain lesion of great size. This case was probably one of encephalitis,— possibly due to poliomyelitis,— and yielded a marked degree of hydrocephalus. This fact, however, did not complicate the estimation of its proper place in the anatomical or psychological series, since the brain was clearly upon the score of weight and simplicity not of so low grade as Case I, but lower than any other brain. Cases I and II, then, appear to be the lowest brains in point of anatomy and the lowest cases in point of intelligence. The comparison may be made even finer, since beyond question the brain of Case I was the least complex of the entire series, and the mentality of this case, whose actual age was but five years, was also minimal.

There are, however, three cases of pronounced microcephaly, namely; cases I, II, and III. The instance of Case III is the most disquieting in the analysis so far from the

standpoint of aligning the brains with estimated mental capacity. Case III, it may be remembered, was that of Little Zip, a microcephalic, who lived for forty-five years a vagrant life, which was almost self-supporting in the hobo sense of the term. With the brains superficially suggestive of a dog, the patient himself exhibited a number of doglike features in his vagrant, happy-go-lucky life, journeying from the barn or house of one friend to that of another. Arranging the brains in the order of their complexity, the brain of Little Zip must be placed third, after the microcephalic case I and the microhydrocephalic case (post-encephalitic) II, and yet the mental age of Little Zip may be safely estimated as about seven years. The mental age is, at all events, much higher than that of the other microcephalics. Thus, if the brains are arranged in order of their estimated age, the brain of Little Zip comes in sixth or seventh place, instead of in the third place.

Another case (IX) may be chosen as well illustrating the possibility of wrongly estimating the mental capacity of a patient from his brain appearances; for this brain was placed upon the score of its complexity, largely in the gross, in the fifth place. Its mental age was seven. Yet two brains that are regarded as still more complex, namely; those of Cases X and VII, yielded Binet ages of $2\frac{4}{5}$ and 5 respectively. The microscopy of Case IX, however, should that be taken into account, would insure a somewhat lower place for the brain of this able-bodied imbecile, of great stature and large, poorly-molded brain (1620 grams; more than 200 grams in excess of an estimated norm). The examples of Little Zip (Case III) and of the able-bodied imbecile (Case IX) suffice to indicate the difficulties of these analyses.

The following table (Table III) shows the brains arranged in the order of their estimated complexity, and the figures in the intelligence column will readily demonstrate the facts just mentioned, concerning the dislocation of cases III and IX from their proper places in the series if we estimated the brains on their gross complexity alone.

TABLE III.

Comparison of Brain Complexity, Brain Weight, and Order of Intelligence in Cases I–X.

Number	Age	Brain Complexity	Brain Weight	Intelligence
I	5	a)	400–, est.	1–, est.
II	20	b)	620	1–, est.
III	45	c)	610	7, est.
VI	26	d)	1130	2, est.
IX	39	e)	1620	7, Binet
X	37	f) or g)	1450	2.4, Binet
VII	25	f) or g)	1270	5, Binet
IV	62	h)	1340	Moron or subnormal
V	16	i) or j)	1435	Subnormal
VIII	36	i) or j)	1340	Subnormal

Table IV arranges the brains in the order of actual brain weight, but gives also the brain weights estimated by Tigges's formula (eight times the body length in centimeters = brain weight in grams). The brain weight for the normal age and sex of the individual taken from Vierordt's tables is also given.

TABLE IV.

COMPARISON OF BRAIN WEIGHT, CORRECTED BRAIN WEIGHTS, AND ORDER OF INTELLIGENCE IN CASES I–X. (Arranged in order of actual brain weight).

Number, Age, Height (cm.)	Brain Weight Tigges	Brain Weight Age normal (Sex)	Brain Weight Actual	Intelligence
I, 5, 81	648	1282, M	400–, est.	1–, est.
III, 45, 126	1008	1348–66, M	610	7, est.
II, 20, subn.	?	1358–96, M	620	1–, est.
VI, 26, 158	1264	1358–96, M	1130	2, est.
VII, 25, 146	1168	1234–39, F	1270	5, Binet
IV, 62, 141	1128	1178–1210, F	1340	Moron or subnormal
VIII, 36, 179	1432	1365–6, M	1340	Subnormal
V, 16, 168	1344	1358–96, M	1435	Subnormal
X, 37, 144	1152	1365–6, M	1450	2.4, Binet
IX, 39, 178	1424	1365–6, M	1620	7, Binet

Table V presents the cases in the order of their estimated intelligence.

TABLE V.

COMPARISON OF ORDER OF INTELLIGENCE WITH COMPLEXITY OF BRAIN IN CASES I–X.

Number	Actual Age	Intelligence	Brain Complexity	Remarks
I	5	1–, est.	a)	
II	20	1–, est.	b)	
VI	26	2, est.	d)	Vocal cord absent
X	37	2.4, Binet	f) or g)	
VII	25	5, Binet	f) or g)	
IX	39	7, Binet	e)	*Out of place*
III	45	7, est.	c)	"Zip," OUT OF PLACE!
IV	62	Moron or subnormal	h)	Almshouse transfer
V	16	Subnormal	i) or j)	Dementia praecox
VIII	36	Subnormal	i) or j)	Murderer

It seems safe to conclude from these tables that at least the brains of least complexity are correlated with the minds of least range, and that the brains of greater complexity are in a general way correlated with minds of greater range. By microscopic correction of the anatomical decisions, we may even cause our figures to look still more satisfactory from the standpoint of identical ordering of anatomical and psychological data. Whether

the future may show how to account for the apparent too-great simplicity of the brain of Little Zip, remains to be seen.

The second point in our epicritical review may be presented briefly, partly on the basis of Table II, in which the findings of exudative lesion or rod cells are entered, and also by means of Table VI, in which are displayed the majority of the anatomical findings in the series. How many of our cases may be regarded as essentially preventable by the means theoretically available to the mental or psychiatric hygiene of the individual, leaving out, that is to say, the eugenic line of attack? Let us, perhaps, grant that Case II, with its focal destructive lesion,— possibly of post-encephalitic origin,— its marked hydrocephalus, marked nerve cell and fibre loss, and marked patchy gliosis, with its focal microgyria in other regions than the most marked post-encephalitic lesion, is a case that is preventable,— that is by social and scientific devices which shall exclude this presumably infectious disease from occurring.

If we take at their face value the slight mononucleosis of cases IV, VI, VIII, and X, we may perhaps consider them as either syphilitic or as suffering from progressive exudative disease of a mild nature, also theoretically preventable. Now, in point of fact, we are far from proving that these four cases are cases of syphilis; or that Case VII, a case which fails to demonstrate lymphocytosis but does demonstrate rod cells, is a case of syphilis. It is, however, of importance to consider that in a series of ten cases of numerous grades of feeble-mindedness, no less than six show processes of a suspiciously progressive nature or suggestive of infection. Here is a problem that is well worth working out in the utmost detail, whether we lay down the problem as a problem of the frequency and distribution of syphilis in the feeble-minded, or whether we seek to establish the part played in feeble-mindedness by acquired disease.

Let us sum up these considerations by saying that the number of cases in which the hypothesis of infection must be more or less firmly entertained is much larger than has been supposed. By consequence, the scales tip much farther for the group of the so-called secondary amentias than was the supposition with most workers.

In addition to these main points in our epicritical review, namely; the point concerning the relation of the complexity of brain to capacity of mind, and the point concerning the theoretical preventability of certain cases, we should not dismiss our review without slightly indicating the richness of the field in points of interest to neurology. The teratologist and embryologist are sufficiently aware of these values, so that we need not make special point of the *Affenspalte* question (for instance, Case I and Case III); the question of cruciate asymmetry (Case V), the question of the absence of the middle commissure (Cases V, VII, IX, and X), the question of presence of dislocated ganglion cells in the white matter

TABLE VI.

Case Number	Calvarium	Dura Mater	Pia Mater	Vessels	Brain Weight Grams	Gyri	Diffuse Atrophy or Aplasia	Focal Atrophy or Aplasia	Corpus Callosum
I	———	———	slight general thickening	negative	400, est.	Microcephaly	marked	variations; "affenspalte" left	proportionate
II	thick frontal; depressions	normal	normal	negative	620	Microcephaly	marked	microgyria, 2nd frontal, etc.	thin
III	moderately	normal	normal	negative; except vertebrals	610	Microcephaly	marked	minor anomalies	proportionate
IV	dense	slight thick, frontal	slight thick, vertex	negative	1340	Focal microgyria and asymmetry	no	minor anomalies	rather thin
V	negative	negative	slight general clouding vertex	negative	1435	Cruciate asymmetry	absent	frontal; opercular	slightly thin, posterior third
VI	inequalities of thickness, brittle	thick along middle meningeals	slight general thickening	negative	1130	simple, symmetrical	absent	Frontal	thin throughout
VII	dense	adherent at corono-sagittal suture line	faintly hazy, vertex and sulci	negative	1270	slight asymmetry; simple construction	absent	Frontal	thin, horizontal portion
VIII	———	———	thickened	negative	1340	slight asymmetry; transverse gyri	absent	left parietal	moderate thinning, posterior third
IX	thick, somewhat dense	thick	focal basal leptomeningitis	negative	1620	slight asymmetry; "poorly moulded"	absent	absent	narrow, posterior third
X	dense	focal thickening	cerebellar pia thickened; pia in general thick	negative	1450	slight asymmetry	general superficial	Frontal	slight thinning, posterior third

TABLE VI (*continued*).

Middle Commissure	Consistence	Sclerotic Foci	Other Foci Destructive	Ventricles Hydro-Cephalus	Cerebellum	Spinal Cord	Remarks
——	——	absent	——	moderate	negative	——	
——	not remarkable	——	left parietal	marked	negative	negative	early focal encephalitis, (poliomyelitic?)
——	not remarkable	absent	absent	0	inferior vermis absent?	negative	
——	not remarkable	absent	absent	present	dentate nuclei unequal		mononucleosis, posterior septum, spinal cord
absent	normal	absent	acquired? slight lesion, left calloso-marginal	slight	negative	negative	
——	normal in general	left 2nd temporal firm, yellow	absent	0	negative	negative	rod cells; lymphocytes in smear, frontal
absent	normal	absent	canalized thrombus (histologically)	0?	negative	negative	rod cells
present	——	absent	absent	0	negative	——	plasmocytosis, focal, left prefrontal
absent	normal; putty-like at base	absent	absent	0	negative	——	
absent	unusually firm; "brain swelling"	absent	absent	0	small	negative	?mononucleosis, focal, right postcentral (dead of pellagra; tuberculous)

(Cases IV and V, and to a slight degree, Case IX), the problem of the time relations of satellitosis (as shown in cases II, III, VI, VIII, and X; and focally, in IV and V), and the question of defective cortex lamina (as shown characteristically in Case IX). We choose for exposition a somewhat more recondite point, namely; the significance of hydrocephalus in some of these cases.

The significance of hydrocephalus in Cases I and II with microcephalic brains is hard to judge. Whether the microcephaly is due to hypoplasia or to agenesia, it would naturally not be unlikely that there should be an absence of neurones, both on the exterior and in the interior, or both in the outer and inner portions of the brain substance. Accordingly the hydrocephalus exhibited in the brains of Cases I and II is not necessarily to be associated with increase of intracranial pressure at any time in the lives of the patients. The hydrocephalus in Case II is very possibly to be related with an early focal acquired lesion of the nervous system (paralytic shock stated to have occurred at three months of age by attending physician). The hydrocephalus in Case III is possibly to be explained similarly, and does not require the hypothesis of heightened intracranial pressure at any time in the life of the patient.

Aside from hydrocephalus associated with microcephaly, and possibly due to the operation of identical causes, we must consider on another basis the hydrocephalus of four other cases: IV, V, VII, and X.

The hydrocephalus of Case IV is voluminous and is associated with a corpus callosum rather thinner than normal, and in fact very thin posteriorly opposite the region of greatest ventricular dilatation. The motor restlessness of this case may or may not be correlated with the ventricular dilatation, as has been contended by Southard in his work on dementia praecox in 1915, and in a later analysis of hydrocephalus in the so-called functional psychoses, as yet unpublished. However, it may well seem to the anatomist that the hydrocephalus would best be regarded as one due to tissue atrophy of a gradual nature, not in any wise necessarily related to alterations of intracranial pressure. The external features of the brain do not show recent effects of ventricular swelling. Accordingly, we should not lay particular stress on the occurrence of ventricular dilatation associated with motor restlessness in Case IV.

Case V shows dilatation of the right lateral ventricle without dilatation of the left (in fact, there may have been a slight degree of internal brain swelling which has caused the surfaces of the left ventricle to come into apposition). This finding of unilateral hydrocephalus has not been infrequent in Southard's dementia praecox series of 1915; has been there referred to at length, and also in the later, as yet unpublished, analysis. In cases VII and X, we are dealing neither with pronounced microcephaly (the brain weights

respectively are 1270 and 1450 grams, accordingly over weight according to Tigges' formula of brain weight in grams equal to eight times the body length in centimeters), nor with the special conditions of a possibly atrophic brain in an imbecile of 62 years, Case IV, and the special features of the case of dementia praecox, Case V. Cases VII and X, curiously enough from our present standpoint, are examples of such an imbecile as is rather apt to be termed by the laymen insane, or "crazy", imbecile. The point of the attendant's or layman's remark is not that such an imbecile belongs in the group of the psychoses as the physician views them, but that the patient is insane or "crazy" from the nonmedical standpoint; showing spells of marked irritability. Thus, Case VII is described as having had tantrums, as being "hysterical" on examination, laughing one minute and crying the next, rushing about, jumping up and down, and screaming on occasion, and was regarded as a very troublesome case.

Case X is described as having been somewhat feeble on admission to the school at the age of 10 years, but as later becoming very troublesome, with quick temper and noisiness.

This problem of the relation of hydrocephalus to hyperkinesis, as first developed from Southard's dementia praecox work of 1915, can hardly be settled in its relation to feeble-mindedness from this series, for if we exclude the three markedly microcephalic cases (Cases I, II, and III), the old demented imbecile (Case IV), the case of dementia praecox (CaseV), and the executed murderer (Case VIII), we are left with but four cases: VI, VII, IX, and X, of which VII and X were hydrocephalic and had been as sketched above as to their tendencies to over-activity. If we consider in contrast to these VI and IX, (the cases we have termed "typical idiot" and "peculiar imbecile" with some capacities above the imbecile grade), we find ourselves dealing with brains of simple construction and of poor moulding respectively, in which brains there is no evidence of hydrocephalus despite the fact that the brains show the corpus callosum in both instances to be thinned out posteriorly. (In fact, the corpus callosum of Case VI is everywhere rather thinner than usual.) Case VI was a very restless and nervous idiot, described as "always looking around," and as "inclined to be destructive". It appears that these tendencies were constant and not more marked at one time than another. The case seemed to be one of slight microcephaly (brain weight, 1130, is 134 grams under Tigges' formula for the patient's height, 158 cm.). "Constant nervousness" or hyperkinesis can hardly be supposed to be associated with hydrocephalus except accidentally and independently of any casual interrelation. The point of the coexistence of overactivity and hydrocephalus in the microcephalic would lodge rather in the simplicity of the neuronic system in the microcephalic case. It is clear that, if the microcephalic brain is *also* hydrocephalic, the neuronic systems of the brain in question must be still simpler in make-up. If the brain in question is

taking in anything like the normal number of ingoing stimuli, and the capacity of the brain to dampen or inhibit the stimuli and divert them from taking effect in motion, is a diminishing capacity, then over-activity becomes the most natural result of the simplicity of the brain and one quite to be expected.

Accordingly, although the typical idiot(Case VI) yielded a brain without hydrocephalus and yet was over-active, it is clear that the over-activity is not of the type of the occasional hysterical outburst; thus, whereas Cases VII and X are described as excitable, Case VI would best be described as restless or "nervous".

Case IX showed no restlessness or excitability at any time, having a good disposition and in general a rather coöperative nature.

Our problem, accordingly, as based on the analysis of this group of cases from the standpoint of hydrocephalus, may be summed up as follows:

The association of internal hydrocephalus with microcephaly may well be incident to the mal-development, that is to say, merely a part of the result of the factors which have retarded or stopped the growth of the brain. Accordingly, under these circumstances, alterations of intracranial pressure are neither necessary nor in fact very likely to occur. Moreover, dilatation of the ventricles in old age and in dementia praecox must be considered separately. If there is any relation between occasional outbursts of excitability and alterations of intracranial pressure which have to do with the production of hydrocephalus, many more cases will be necessary to make the point certain. We have one good instance to show that *constant* restlessness is not necessarily associated with hydrocephalus. A further physiological and psychological analysis of the difference between excitability and restlessness would be very desirable, both for its intrinsic interest and for the light it may throw upon these structural conditions, which are difficult, if not impossible to interpret when considered entirely by themselves.

Summary.

The entirely provisional conclusions of the epicritical review may be briefly stated as follows:

First, it is not impossible that the problem of matching brain complexity with mental capacity may be solved by a much larger series of instances than is here available; but the instances of such matching as has been undertaken are somewhat convincing as to the correlations of low orders of intelligence with simple brains and of higher orders of intelligence with more complex brains. Occasional exceptions to the rule may be explained by

the finer anatomy of certain cases (Case IX); others remain less easy to explain away (Case III).

Secondly, the partial orienting and microscopic examination yielded more instances of slight exudative lesions (including in some instances rod cells) than might have been *à priori* expected from a relatively stable institutional material like that here largely drawn upon. What the share of syphilis in this group of cases may really be is doubtful. There was one instance of feeble-mindedness very possibly due to an early focal encephalitis entailing mal-development of brain.

Thirdly, as an example of special neurological interest attaching to this study, some considerations about hydrocephalus offered bring up the question of the relation between occasional bursts of excitability and alterations of intracranial pressure with the production of hydrocephalus.

Description of Photographs.

Views of Case I.

The gross photographs of the stripped brain alone are presented since, although there was a slight general thickening of the pia mater, the microscopy of the tissue has so far shown no evidence of exudate.

Note in photographs I–a, I–c, and I–d the striking projection of the cerebellum behind the occipital poles. Note the suggestion of *Affenspalte* (I–a).

Note in I–b the large exposure of the crura cerebri, as well as the comparatively small number of transverse pontine fibres arranged in almost distinct bundles. Note, also, in I–b the comparative size of the optic tracts and olivary eminences.

Note in I–a, I–c, and I–d the bi-convolute construction of the frontal lobe; the superior frontal convolution, broader than the inferior, may represent superior and middle frontal convolutions of more highly developed brains. Note the excellent development of the pyriform lobule on each side, especially the right (I–b).

We present in I–e, I–f, and I–g, three views of the brain in total section as stained by the Weigert myelin sheath method. (Note that the stains are relatively successful despite the preservation of the brain for eleven years in formaldehyde solution.) A moderate degree of hydrocephalus is notable in I–f. The small size of the leaflets of the cerebellum is to be noted in I–g. The comparatively greater depth of the sulci than those found in more normal brains is obvious in each of the total brain section views.

This case is thought to have possessed the lowest mental age in the entire series. An older sister of the patient was almost equally defective and almost identically microcephalic; other children, before and after, were not microcephalic.

Views of Case II.

The gross photographs of the stripped brain alone are presented since the membranes were normal and there were no microscopic evidences of exudative disease.

Photograph II–a demonstrates the focal posterior-lying areas, especially marked on the left side with microgyria. This case of microcephaly exhibits a higher degree of hydrocephalus than did Case I, as is demonstrable from the total brain sections II–f, II–g, and II–h. II–a also shows frontal depressions corresponding with depressions in the skull. Note in II–a, II–c, and II–d the distinct projection of the cerebellum behind the occipital poles; a projection less marked than in Case I.

Note in II–c an area of microgyria in the second frontal gyrus; a similar area is less marked in II–d. II–a demonstrates that the area of microgyria begins almost abruptly with the postcentral gyrus; whereas the precentral gyrus on each side is of fair width and well rounded. Photographs II–c and II–d demonstrate that the microgyria is far less marked on the flanks and inferiorly than superiorly; and this contrast is strongly brought out in the total brain section view, II–g and II–h.

The mental age of this case was, also, one year or less, but the intelligence of the patient was greater than that of Case I. Clinical observation of the patient's general behavior indicated that he was in the habit of attending to bright colors, looking at pictures, watching boys at play, and taking interest in events about him. The question arises, whether these functions are largely related so far as they are of visual origin with the inferior rather than the superior tissues of the occipital lobe. It may be noted that the Weigert myelin sheath stains are relatively successful with this brain although it was preserved in formaldehyde for 13 years.

Views of Case III.

The views of this case are, also, limited to the stripped brain for the same reasons as in Cases I and II. Note the general symmetry of this brain. The views do not include the cerebellum, which, however, did not project beyond the plane of the occipital poles. Note in III–a the suggestion of *Affenspalte* on the right side.

Note that the gyri are everywhere narrow and simple in arrangement, and that the secondary sulci are rarely complicated by collaterals. A special description in the text is made of the parietal regions, which in III–a are quite unlike.

III–c and III–d show at the base of the frontal gyri, separating them from the precentral convolutions, short, deep, transverse sulci, somewhat suggesting the sulcus cruciatus of the brain of a dog. Note, in fact, the somewhat general superficial resemblance of the brain of this case to that of a dog.

Views of Case IV.

Views IV–a and IV–b are presented of the unstripped brain viewed from above and below, partly because there is a slight thickening of the pia mater at the vertex, and partly because microscopic examination showed a mononucleosis of the posterior septum of the spinal cord, which naturally gives rise to the suspicion of former syphilis, although it

fails to prove the existence of syphilis. IV–c and IV–d show the same aspects with the pia mater stripped.

IV–c, IV–e, IV–f show a lack of division of the primary sulci of the frontal lobe on account of the interruption of annectants. The parietal convolutions are also narrow: IV–c, IV–e, IV–f.

IV–d shows a right pyriform lobule larger and more prominent than the left. Now, the left side of the brain in general appears slightly more hypoplastic (or atrophic?) than the right, so that Case IV exhibits a diminution of the crossed and uncrossed systems on the same side of the brain. (We here proceed upon the basis that the connections of the left pyriform lobule are largely with the left olfactory zone, whereas the connections of the neopalium are largely crossed.) Compare, accordingly, the cruciate asymmetry which appears in Case V. We might argue that the conditions in Case IV are of more recent origin than those of Case V. At least, if we desire to attribute the cruciate asymmetry of Case V to the operation of a single agent at or before the beginning of decussation, of course this case,— the oldest in the series,— was microscopically found subject to gliosis, and the whole brain shows a tendency to atrophy with slightly flaring sulci. It may be that the condition is one of atrophy and not of aplasia, and that the atrophy has little or nothing to do with the feeble-mindedness of the case.

The gross sections are presented with some completeness (four views, IV–g to IV–j) for the reason of the somewhat surprising degree of hydrocephalus which the external views would hardly give one cause for suspecting.

The best argument for feeble-mindedness in this case is microscopic, namely; the presence of dislocated ganglion cells in the white matter.

Views of Case V.

The unstripped views of Case V are omitted, as in several previous cases, because of the lack of acute or progressive exudative process.

V–a presents the not unusual frontal and occipital cruciate asymmetry. In this instance, the left frontal and left occipital lobes are smaller than their fellows. The mesial views V–g and V–h show a slight amount of thinning out in the posterior third of the corpus callosum.

As in Case IV, the best argument for feeble-mindedness in this case is microscopic, namely; the presence of dislocated ganglion cells in the white matter. Naturally, this argument may not be convincing. In general, the gross findings in the case resemble

those of dementia praecox in their mildness and unilaterality. These appearances are borne out in a cross section (V–d).

Views of Case VI.

Unstripped appearances from above and below are presented in VI–a and VI–b, because there was not only a general thickening of slight degree of the pia mater, but lymphocytes were found in a smear from the frontal region as well as a few rod cells in certain areas. These appearances may well suggest syphilis. But one focus of perivascular lymphocytosis has been found in the microscopic study, which was in this instance chiefly limited to the stripped brain. Despite the indication of syphilis, this case was a rather typical instance of a "grinning idiot", who was perhaps classed too low under the Binet test because of his aphasia, which aphasia may have been in part due to the absence of one vocal cord. There were certain other suspicions of syphilis in the case. The corpus callosum was thin throughout (see especially VI–g and VI–h).

Views of Case VII.

The unstripped appearances in Case VII, viewed from above and from below, are likewise shown, although the pia mater was but faintly hazy throughout. The microscopic examination, however, demonstrated rod cells, from which may perhaps be suspected a more progressive condition than is assumed to be typical of feeble-mindedness. The mental age of this case, though set at five, seemed too high in a number of respects. The case also showed some sensory disorder. As in Case VI, there was apparently a suspicion of syphilis.

The views of the stripped brain exhibit a fairly complex construction. The cross sections, VII–g and VII–h, show a narrow corpus callosum.

Views of Case VIII.

On account of the focal plasmocytosis of the left prefrontal area, the unstripped views of the vertex (VIII–a), the left flank (VIII–b), and the left mesial surface (VIII–c) are presented. There was no suspicion of syphilis in this case clinically, and it may be that the condition found is due to some other intercurrent condition, which may possibly have set in even after the crime for which the patient was executed. The stripped appearances show a number of transversely directed gyri and a failure to approximate on the part of the summits of numerous gyri. This is especially shown in the view of the left flank (VIII–b).

Perhaps the strongest argument for feeble-mindedness in the case is the dislocated ganglion cells in the white matter of certain areas (very few). The narrowing of the posterior third of the corpus callosum is best shown in the mesial views VIII–c, VIII–e; less well in VIII–f, VIII–g, VIII–h, and VIII–i.

Views of Case IX.

The unstripped appearances in Case IX are presented from above and below (IX–a and IX–b) and mesially (IX–c and IX–d) to exhibit a focal leptomeningitis. especially at the base. But there was no evidence of acute or chronic inflammation microscopically.

The stripped appearances (IX–e to IX–j) show slight asymmetry and a brain in general of great size but poor molding. The mesial views (IX–i and IX–j) show a narrowing of the posterior third of the corpus callosum.

Views of the brain in cross section are shown with comparative fulness on account of the irregularity in the distribution of hypoplasia as suggested by the microscopic examination. Especially the right superior frontal region (IX–k) exhibited the most marked architectural disturbance microscopically. A cyst-like area in the right hemisphere of IX–l is due to artifact.

Views of Case X.

Photograph X–a illustrates the unstripped appearances, to which are added X–b and X–c to illustrate the thickening of the cerebellar pia mater. The case exhibited a somewhat questionable focal mononucleosis about the vessels of one region.

Microscopic examination showed numerical hyperplasia of cells in a number of places. The brain is fairly complex in construction, but the corpus callosum (X–h and X–i) shows a slight thinning in the posterior third.